THE ORIGIN AND VEGETATION OF SALT MARSH POOLS.

(PLATES IX–XIV.)

BY JOHN W. HARSHBERGER, PH.D.

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The natural, undisturbed surface of the salt marshes of our eastern Atlantic coast is fairly uniform in character (Plate IX., Fig. 1) from Cape Cod south, as far as the mouth of Chesapeake Bay. They are formed at the mouths of rivers, which empty into the ocean, and behind the barrier islands of sand, which fringe the coast, in the quiet waters of the lagoons which become fringed with salt marshes of varying width (Plate IX., Fig. 2), or the open lagoons, or bays, are completely invaded and converted into a salt marsh of fairly large size. The tidal channels, or thoroughfares, as they are called in New Jersey, still permit the entrance of sea water and the surface of the marsh is partly, or wholly, flooded with water depending upon the state of the tide.

The outer margin of the salt marsh where it touches the open lagoon (Plate IX., Fig. 2), or the tidal thoroughfare, is fringed with a broader, or a narrower strip of the tall salt grass, *Spartina glabra* (Plate X., Fig. 1), depending upon the level and slope of the marsh surface. Back of this strip, or association, we find the rush salt grass, *Spartina patens,* which grows at a slightly higher tidal level, and is of varying width and outline, and then come the extensive areas of the black grass, *Juncus Gerardi,* upon which the economic value of the marsh depends. Sometimes there are extensive areas covered with the lesser salt grass, *Distichlis spicata.* The samphire, *Salicornia europæa,* grows sometimes in pure association, sometimes mingles with *Spartina patens* and *Distichlis spicata,* while the sea-lavender, *Limonium carolinianum,* also grows in association with the grasses and samphire in places over the surface of the marsh, as also *Suæda maritima* and *Atriplex patula.* Where fresh-water con-

ditions begin to prevail, that is along the inner tension line of the salt marshes, we find *Hibiscus moscheutos, Baccharis halimifolia* and *Iva frutescens* along with *Ptilimnium capillaceum, Cicuta maculata, Myrica carolinensis* and other plants, either in front of, or in the center of the thicket vegetation.

The surface conditions, which we have described above, may be disturbed by the action of strong eddying currents of wind, which blow across the salt marsh. The grasses and other marsh species are blown down and become matted and twisted, so that marsh surface has a billowy apearance (Plate X., Fig. 2) with extensive areas of erect marsh plants, and depressed portions of greater or less size of prostrated grasses. With exceptionally high tides, which carry the dead stems, leaves, and other remains of the marsh plants about with them, the floating material is carried in over the marsh and deposited upon the surface of the salt marsh plants, especially in the hollows of the grassy surface, which have been caused by the wind (Plate X., Fig. 2, and Plate XI., Fig. 1). These rafts of vegetable debris are left on the surface of the marsh with the tidal retreat, and as the water level may not rise again to a similar level for several days, or even months, the drift material smothers the growing plants beneath it, and rapid decay sets in. This smothering action may be effective in larger or smaller areas of the marsh (Plate XI., Fig. 1), and the tops of the plants are not only destroyed, but the decay reaches the underground parts as well. Not only are the underground parts destroyed, but also the surface of the salt marsh sod, which is above the permanent ground water level. Depressions in the salt marsh are thus formed, which vary in size from a few feet across to areas an acre or more in extent. These depressions usually have steep sides and become filled with water at high tides, and thus constitute the typic salt marsh pools (Plate XI., Fig. 2; Plate XII., Fig. 1) which are in evidence in every salt marsh along the Atlantic coast.

Various algæ begin to grow in these quiet pools (Plate XI., Fig. 2), and an investigation of the algæ found in such pools at Cold Spring Harbor, Long Island, showed the presence of the following blue green algæ: *Lyngbya semiplena, Microcoleus chtonaplastes, Oscillatoria limosa, Rivularia atra* and such diatoms as

Pleurosigma angulatum, Melosira nummuloides and a species of *Navicula* and *Synedra.* With the retreat of the water and the drying up of the pools, these algæ and diatoms form crusts, or matted masses (Plate XII., Fig. 2), mixed with the dried leaves of *Zostera marina* and the remains of other plants. In one pool pieces of newspaper were found stuck together by the mat of blue green algæ. The mats of partially dry algæ and diatoms (algal paper) assist in the further disintegration of the peaty surface of the pool bottom, but a limit is reached beyond which the process of decay is checked. With a change in drainage of the salt marsh, some of the pools are only occasionally filled with salt water, and the algæ begin to die and disappear, leaving a barren soil, which in very dry weather may sun crack, as shown in the photograph of such a pool in the salt marsh back of Atlantic City, New Jersey (Plate XIII., Fig. 1). Such denuded areas are now invaded by typic salt marsh species. One such pool investigated was tenanted by a pioneer plant, *Atriplex patula,* while an old crescent-shaped depression was completely invaded by *Triglochin maritimum* in pure association, and another area with *Pluchea camphorata, Plantago maritima Solidago sempervirens.* Still another bare area was invaded by *Spergularia marina, Plantago maritima* and a few weak plants of *Solidago sempervirens.*

An extensive area completely denuded of vegetation by the smothering action of drift material and completely riddled with the burrows of the fiddler crabs, *Gelasimus pugnax* (Plate XIV., Fig. 1), was found occupied by a pure association of the samphire, *Salicornia europæa,* which is frequently the pioneer species on such mud flats (Plate XIII., Fig. 2). Not all of the areas in our eastern salt marshes are due to the smothering action of the drift material, which consists largely of the dried remains of *Spartina glabra* and *Zostera marina,* but occasionally, we find a sloping gravel bank, as at Cold Spring Harbor, Long Island, where a fresh-water spring controls during a large part of the day the soil conditions, and where the gravel soil is so hard as to preclude the growth of the usual salt marsh species (Plate XIV., Fig. 2). Under such conditions *Lilæopsis lineata* grows. It is an interesting little umbelliferous plant with fleshy spatulate leaves, a running stem, and a

small umbel of white flowers. During part of the day it is exposed to submergence by salt water and during the rest of the day, its leaves are subjected to the action of air and sunlight, while its roots and creeping stems are influenced by fresh water. Such a plant must change its osmotic relations several times a day, alternately being exposed to the action of salt and fresh water. It was under such conditions of environment that the plant was first detected in New Jersey by Thomas Nuttall, who found it near "Egg Harbor," apparently near Beesley's Point.

Soon the typic salt marsh species such as *Spartina glabra, S. patens, Distichlis spicata, Juncus Gerardi* gain access to the barren ground occupied by the pioneer species (Plate XIII., Fig. 2; Plate XIV., Fig. 1), which are gradually replaced by the plants which are dominant in the salt marsh. After these vicissitudes of salt marsh existence, we find the climax vegetation restored, and the areas formerly denuded by the smothering action of drift material and algæ appear again, and the usual flat, featureless, meadow-like physiognomy of the salt marsh surface appears again (Plate IX., Fig. 1). In the study of the origin of salt marsh pools, we have traced the successional history of plants which are normal constituents of the salt marsh flora, but which become associated together in a different way upon the genesis of the pools of larger and smaller size, which are typic features of the meadow-like expanses of our eastern Atlantic halophytic marshes. As the genesis of the pools with their algæ and other species of flowering plants are due directly to the action of the tides in carrying the flotsam and jetsam of salt plants over the surface of the marsh, so with the elevation of the marsh, and the absence of the daily or periodic flooding of the surface with sea water, we find a cessation in the formation of tidal pool formation and the permanence of a level, uniform surface of salt marsh, which may later change its physiognomy and floral character, when fresh-water conditions come to prevail. The ecologic succession of such converted areas of salt marshes is an entirely different problem, but its essential feaures have been described previously in a paper[1] entitled "The Reclamation and Cultivation of Salt Marshes and Deserts."

[1] Harshberger, John W., *Bulletin of the Geographical Society of Philadelphia,* July, 1907.

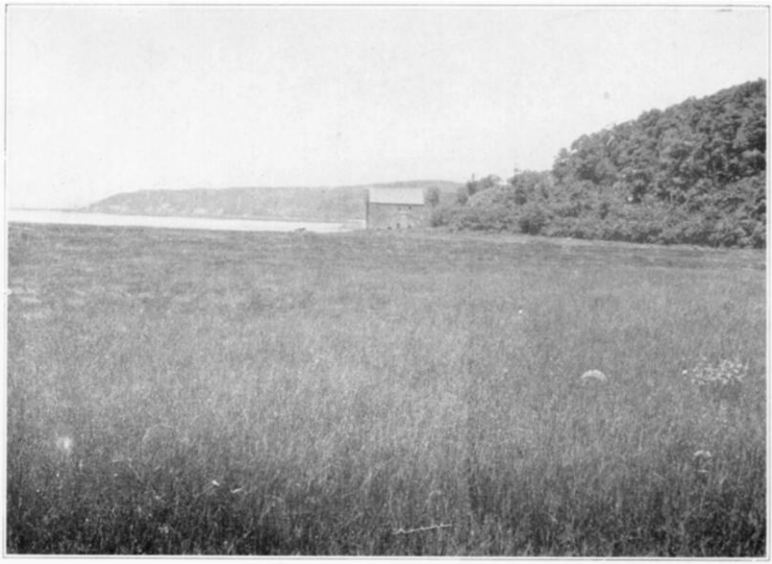

FIG. 1. General view of meadow-like surface of salt marsh at Cold Spring Harbor, Long Island, looking north toward Harbor, July, 1913. The area of the middle ground is occupied by an association of *Juncus Gerardi*.

FIG. 2. Lagoon and fringing salt marsh back of Atlantic City, New Jersey, June 23, 1914.

FIG. 1. Tall salt grass, *Spartina glabra,* fringing salt marsh at Cold Spring Harbor, Long Island, August, 1914.

FIG. 2. Surface of salt marsh at Nantucket, Massachusetts, billowed by the wind, August, 1914.

FIG. 1. Billowed surface of salt marsh at Cold Spring Harbor covered with drift material which smothers the other plants, July, 1914.

FIG. 2. Salt marsh pool back of Atlantic City, New Jersey, June 23, 1914. The algæ will be noted growing in the upper right side of the pool.

FIG. 1. Salt marsh pool at Nantucket, Massachusetts, August, 1914, surrounded in part by tall salt grass, *Spartina glabra.*

FIG. 2. Dry salt marsh pool at Cold Spring Harbor, Long Island, with dry crusts of algæ, July, 1914.

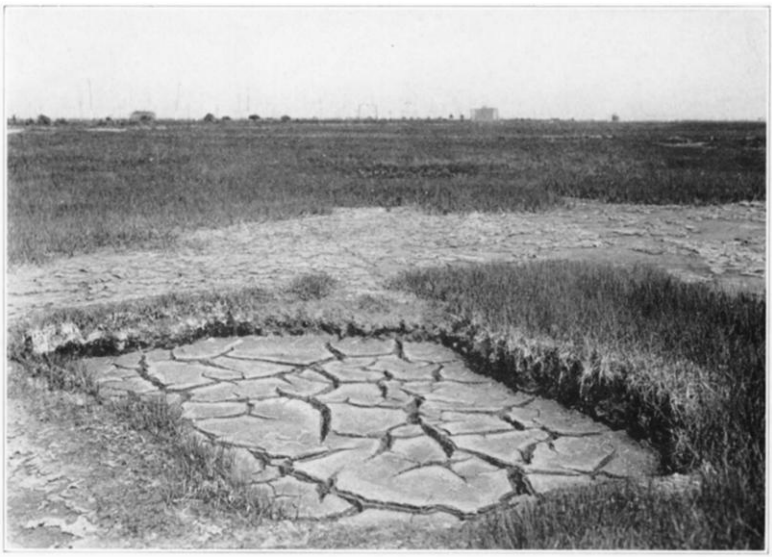

FIG. 1. Dry salt marsh pool back of Atlantic City, New Jersey, showing mud cracked with sun cracks, June 23, 1914.

FIG. 2. Denuded area in salt marsh at Atlantic City, New Jersey, re-invaded by samphire, *Salicornia europaea,* June 23, 1914.

FIG. 1. Denuded area in salt marsh at Cold Spring Harbor, Long Island, riddled by burrows of fiddler crabs and reinvaded by pioneer vegetation of samphire, July, 1914.

FIG. 2. Gravelly area at inner margin of salt marsh at Cold Spring Harbor, Long Island, July, 1914, controlled during low tide by fresh water and occupied by *Lilaeopsis lineata,* which is submerged at high tide.